

The self-efficacy of education students in understanding materials and mathematical problem-solving

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ABSTRACT

The present study investigates the self-efficacy (SE) of education students concerning their understanding of educational materials and mathematical problem-solving skills. SE, a crucial motivational construct, plays a vital role in academic achievement and cognitive development. The research employed a quantitative approach, utilizing a structured questionnaire to collect data from 155 mathematics education students and 67 biology education students. The questionnaire using a Likert-type scale comprised two main sections: one assessing SE beliefs related to understanding educational materials and the other focusing on SE beliefs associated with mathematical problem-solving. The data analysis was performed using descriptive and inferential statistical methods, including correlation analysis and independent t-tests by JASP 0.16.3.0. The findings provide valuable insights into the SE of education students in the context of different disciplines. The study reveals the overall SE levels of mathematics and biology education students in understanding educational materials and mathematical problem-solving are moderate level. There is no significant relationship between the SE of mathematics and biology education students in understanding materials and mathematical problem-solving. However, there are significant differences in SE for both understanding materials and mathematical problem-solving between the two groups. The implications of these findings for instructional practices are discussed.

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1. INTRODUCTION

Mathematics is the foundation for many professions, especially science, technology, and engineering. However, mathematics is often considered difficult, and many students leave science, technology, engineering, and mathematics (STEM) disciplines [1]. As a result, careers in engineering and technology, as well as those that require mathematics, are closed. Although not all students fully claim to dislike or hate mathematics as an academic discipline [2], [3]. However, most students still need help to learn mathematics. Problems in learning mathematics relate to what and how to teach mathematics and what is essential for students to learn in and through mathematics. The goals of learning mathematics include understanding material concepts and solving problems [4]. Mathematical problem-solving refers to the process of using mathematical concepts and strategies to solve complex problems or non-routine problems and is related to a sequential and systematic process of obtaining better and correct results [5]–[8].

Based on the results of the trends in international mathematics and science study (TIMSS), a study related to mathematics and science organized by the international association for the evaluation of educational achievement (IEA) states that the mathematical abilities of students in Indonesia are still below the international average [9], [10]. The results indicate that students' problem-solving abilities still encounter various difficulties. The problem-solving skills of students can be influenced by a range of factors. Taking a holistic perspective, these variables affecting problem-solving skills can be broadly categorized into two groups: cognitive and affective [11]. The cognitive aspect, specifically reading comprehension, and metacognition. Reading comprehension encompasses several key elements, such as identifying the suitable title, discerning the main and supporting ideas within the text, recognizing cause-effect relationships, and predicting the meanings of unfamiliar words [12]. This skill plays a crucial role in comprehending problems during the problem-solving process and understanding intricate issues [13]. When individuals encounter a problem, their initial approach involves seeking to comprehend it thoroughly. Furthermore, problem-solving skills can also be influenced by metacognition, the need for cognition, and intelligence [14].

Affective variables may not have a direct impact on problem-solving skills, but they can exert an indirect influence. Individuals who lack confidence in their problem-solving abilities tend to invest less time in tackling problems, making the problem-solving process more challenging for them. Among the crucial variables discussed in this study that have a relationship with affective aspects is self-efficacy (SE) [15]. Self-confidence (self-efficacy and self-concept) are two factors that significantly influence motivation and student learning outcomes from a cognitive, social, or psychological perspective [16]–[18]. Self-concept and SE are self-perceptions related to competencies that influence student success in education [17], [19]. Self-concept ability is a mental representation of a student's abilities in the academic field in general or in a particular academic field.

SE is defined as the belief in one's capacity to accomplish tasks or demonstrate skills effectively [20]. SE refers to students' belief that they can master a given academic task at a specified level [17], [19], an individual's belief in their ability to successfully perform a specific task or achieve a desired outcome [11], [21], [22]. It plays a crucial role in motivation, learning, and behavioral change. SE beliefs influence how individuals think, feel, and behave, affecting their effort, persistence, and emotional responses in various tasks and challenging situations [22]. Math SE refers to a child's belief in their ability to perform well in mathematics and plays a mediating role in the relationship between parenting style and math anxiety, suggesting that enhancing children's belief in their math abilities can help alleviate math anxiety [21]. Students' SE perception in mathematics, along with reading comprehension and mathematics attitude, plays a significant role in their ability to solve non-routine mathematical problems [11] and is a significant predictor of students' academic achievement, particularly in their performance in mathematics tests and courses [22].

SE is the belief in finding, organizing, and carrying out a task to achieve a goal. Confidence helps deal with problems in everyday life. The level of student SE is closely related to solving problems or assigned tasks and learning achievement [23], [24]. Students with high SE abilities will focus more on finding solutions to problems than thinking about their deficiencies [25], [26]. Students in the high SE category can master the three indicators of students' mathematical understanding abilities: translation, interpretation, and exploration. Students in the low SE categories only master translation but cannot achieve interpretation and exploration indicators. Thus, students who have high or low SE can master indicators of mathematical understanding in determining to problem-solve and have a good self-concept [27].

Several studies on SE are associated with problem-solving [11], teacher professional development [28], and the majority is associated with motivation and performance [21], [22], [29], [30]. Given the remarkable importance of SE in the acquisition of mathematical knowledge and problem-solving abilities, coupled with the restricted number of research investigations focusing on SE among educational students, especially in the area of understanding content and solving problems, it is imperative to conduct research in this domain. Education students hold a crucial position in molding the mathematical competencies and problem-solving proficiencies of forthcoming generations. Thus, comprehending their SE levels in these areas is essential for enhancing teaching methodologies and advancing educational results. Through exploring SE within this specific group and setting, valuable insights can be acquired into the elements that impact their academic performance, thereby contributing to the formulation of efficient interventions and strategies to bolster their educational journey.

While previous research has extensively examined SE in relation to motivation, academic performance, and teacher development, studies focusing on the interplay between SE in content comprehension and mathematical problem-solving abilities among education students remain limited. This study fills that gap by investigating how SE in understanding subject matter correlates with SE in solving mathematical problems, particularly among mathematics and biology education students. Furthermore, by analyzing discipline-specific variations in SE levels, this study provides new insights into how SE differs between students from distinct academic backgrounds and how these differences may influence future instructional strategies. The findings are expected to contribute to the development of targeted interventions

aimed at strengthening SE and enhancing problem-solving skills among future educators, ultimately improving mathematics instruction quality in educational settings. Based on this description, this paper aims to answer the following questions:

- i) What is the SE of biology and mathematics education students in understanding the material, and their SE in solving mathematical problems?
- ii) Is there a significant relationship between the SE of mathematics and biology education students in understanding the material and the SE of education students in solving mathematics problems?
- iii) Is there a significant difference in the SE of mathematics and biology education students in understanding the material and student's SE in solving mathematics problems?

2. METHOD

2.1. Types and approaches

This type of research was a survey with a quantitative approach. This is because the research objectives are to describe the level of students' SE, analyze the relationships among relevant variables, and test differences in SE related to understanding material and solving mathematical problems among students in biology and mathematics education programs [31]. The quantitative approach is appropriate as it allows for the collection of numerical data and the application of statistical techniques to examine patterns and test hypotheses.

2.2. Participant

The research participants were students from Muhammadiyah Malang's Faculty of Teacher Training and Education, with 155 (62%) studying mathematics education and 74 (44.6%) studying biology. These participants are appropriate for survey research with a sample size of more than 30% [31], [32]. These two study programs were chosen because they fall into the mathematics and science category, which includes students who have taken mathematics/statistics or research methods courses. Grade level, perception of one's abilities, and level of motivation are a confounding factor in research on student SE [33]–[35]. As a result, the research participants were in adjacent semesters: mathematics education students in semesters 4 and 6, and biology education students in semesters 6 and 8, respectively. The average academic achievement index of students who participated was relatively similar to mathematics and biology education, namely 3.46 and 3.63, respectively.

Furthermore, the heads of the mathematics and biology education study programs gave their permission for this research. All participants voluntarily completed the Google Form asking about their SE in understanding the material and solving problems. All participants' identities are strictly confidential.

2.3. Instruments

The research instrument used in this study was a student SE questionnaire for understanding material, which consisted of eight statement items, and solving mathematics problems, which comprised nine statement items. Each item has a choice of level of confidence/confidence between 0 and 10 [36]. All items were found to be valid through Person correlational analysis with a p -value < 0.05 . The SE instrument in understanding material has a reliability value of 0.93 (McDonald's ω) or 0.78 (Cronbach's α), indicating reliability. The validity of the student SE questionnaire in understanding the material from items 1 to 8 was 0.61, 0.76, 0.84, 0.89, 0.89, 0.82, 0.71, and 0.56. Meanwhile, the validity of students' SE items in solving mathematics problems was 0.66, 0.71, 0.75, 0.87, 0.89, 0.58, 0.76, 0.70, and 0.61. The instrument is reliable, as indicated by a McDonald's ω value of 0.93 or a Cronbach α value of 0.75.

2.4. Data analysis

Before analysis, the data was validated. Validation was done in two ways: identifying and evaluating outlier data that may hurt the analysis and determining the validity and reliability of the instruments. All instruments are reliable, and all items are valid. According to the results of identifying and evaluating outlier data, 7 biology students out of 74 made errors when filling out the instrument, including entering more than one value in one of the instrument items. So, valid data comes from 155 mathematics education students and 67 biology education students.

Descriptive statistics (mean and standard deviation (SD)) for all variables were calculated about student SE in understanding the material and solving mathematical problems. Then, the categories are high, moderate, and low. High category if the score, $x > Mean + 0.5 SD$, moderate if the score is $Mean - 0.5 SD \leq x \leq Mean + 0.5 SD$, and low if the score is $Mean - 0.5 SD < x$. The correlational test uses Person correlation to test whether there is a significant relationship between student's SE in understanding the material and solving mathematical problems. Independent sample t-tests were used to test

whether there were significant differences between student SE in understanding the material and solving mathematic problems for mathematics and biology education students. The t-test is a powerful statistical test that can be used to determine whether two sets of sample data are significantly different from each other when they have different sizes and unequal variances [37], [38]. All tests used the level of statistical significance at $p < 0.05$ and used JASP software version 0.16.3.0 for Windows.

3. RESULTS AND DISCUSSION

3.1. Results

The results of this study are presented based on the research objectives, which include describing the level of students' SE, analyzing the relationships between relevant variables, and examining differences in SE related to understanding mathematical concepts and solving mathematical problems. The analysis compares students from biology and mathematics education programs, providing a clearer picture of how their academic background might influence their confidence in dealing with mathematical content and problem-solving tasks.

3.1.1. Description of self-efficacy understanding material and solving mathematical problems

In general, statistical descriptions of SE in understanding material and solving mathematical problems are presented in Table 1. Based on Table 1, the mean SE of mathematics and biology education students in understanding the material and solving math problems is relatively similar. This finding suggests that, on average, both groups of students tend to exhibit comparable levels of SE in these specific aspects of their academic pursuits. Further, this finding highlights the importance of promoting SE beliefs among students in understanding the material and solving math problems, as it can positively influence their academic performance, motivation, and overall learning experience. Additionally, it underscores the significance of identifying and addressing individual differences in SE to ensure that all students receive the support needed to thrive academically in their respective disciplines. Based on the means and SD, categories of high, medium, and low are established for SE in understanding the material and solving math problems. The results of the descriptive analysis regarding SE in understanding the material and SE in problem-solving for mathematics and biology education students are presented in Tables 2 and 3, respectively.

Table 1. Mean and SD of SE in understanding the material and solving mathematical problems

Variable	Mathematics students		Biology students	
	Means	SD	Means	SD
SE in understanding the material	46.25	14.93	48.78	14.41
SE in problems solution	58.63	17.48	58.41	17.11

Table 2. Descriptive statistics for mathematics students

Variable	SE-understand the material			SE-problem-solving		
	Low	Moderate	High	Low	Moderate	High
Valid	25	101	29	23	106	26
Missing	0	0	0	0	0	0
Means	22.480	46.284	66.724	33.957	58.264	81.962
SD	6.430	8.029	4.728	6.657	9.903	4.771
Minimum	9.000	32.000	62.000	19.000	43.000	75.000
Maximum	31.000	61.000	78.000	42.000	73.000	90.000

Table 3. Descriptive statistics of biology students

Variable	SE-understand the material			SE-problem-solving		
	Low	Moderate	High	Low	Moderate	High
Valid	35	18	14	10	45	12
Missing	0	0	0	0	0	0
Means	37.229	56.778	67.357	30.700	58.467	81.333
SD	8.822	3.889	3.296	4.296	10.567	4.793
Minimum	11.000	50.000	63.000	24.000	44.000	76.000
Maximum	48.000	62.000	75.000	35.000	75.000	89.000

Based on Table 2, the descriptive statistics with a sample of 155 students showing that students' SE variable in understanding mathematics material, shows that in the low category, there are 25 students with an average of 22.480; in the medium category, there are 101 students with an average of 46.284, while for the

high category, there are 29 students with an average of 66.724. As well as the student SE variable in solving math problems shows that there are 23 students in the low category with an average of 33.937. In the medium category, there are 106 students, with an average of 58.264. the descriptive analysis provides insights into the distribution of students' SE scores in understanding mathematics material and solving math problems. The findings reveal variations in students' confidence levels, with some students having lower SE, some demonstrating moderate SE, and others displaying higher SE in both aspects. These findings are important for teachers as they can help identify students who may require additional support and interventions to enhance their SE in mathematics, thus potentially improving their academic performance and overall learning experience [22]–[25].

Based on Table 3, the descriptive statistics shows that students' SE variable in understanding mathematics material, shows that in the low category, there are 35 students with an average of 37.229; in the medium category are 18 students with an average of 56.778; while for the high category, there are 14 students with an average of 67.357. As well as the student SE variable in solving math problems shows that in the low category, there are ten students with an average of 30.700; in the medium category, there are 45 students with an average of 58.467; and in the high category, there are 12 students with an average of 81.333. The descriptive analysis provides insights into the distribution of students' SE scores, indicating variations in their confidence levels when it comes to understanding mathematics material and solving math problems. The findings highlight the importance of addressing and nurturing students' SE, especially in areas where it appears to be lacking, as it can significantly impact their learning outcomes and overall performance in mathematics [39].

The results of the descriptive analysis shows that student SE in understanding the material and student SE in solving math problems for biology and mathematics education students include low, medium, and high categories. This is in line with the research that the influence on basic programming concepts is enormous, especially for students with moderate and low SE [40], [41]. The influence of students' SE and learning concepts can increase the efficacy of students' self-learning, demonstrated by conceptual understanding, high-level cognitive skills, practice, and communication [40], [41].

3.1.2. Correlation between self-efficacy understanding material and solving mathematical problems

Before conducting the Pearson correlation, the multivariate normality of the data was tested using the Shapiro-Wilk test, yielding a result of 0.91 with a p-value of less than 0.01. Thus, it indicating that the data is normally distributed. The results of the correlational analysis between SE in understanding the material and SE in solving problems using the Person correlation for mathematics and biology students are presented in Table 4.

Table 4. Pearson's correlation SE Mathematic and biology students

Variable		SE PMmat	SE PMbio	SE-MMmat	SE-MMbio
1. SE_PMmat	Pearson's r	—			
	p-value	—			
2. SE_PMbio	Pearson's r	-0.03	—		
	p-value	0.84	—		
3. SE-MMmat	Pearson's r	0.70	0.16	—	
	p-value	<0.001	0.19	—	
4. SE-MMbio	Pearson's r	0.06	0.05	9.63e-3	—
	p-value	0.62	0.69	0.94	—

Note: SE_MMmat (SE_MMbio) is a brief from SE mathematics (biology) education students in understanding the material. SE_PMmat (SE_PMbio) is a brief from SE mathematics (biology) education student in mathematical problem-solving.

Based on the results of the Pearson correlation test in Table 4, it indicates a strong correlation between mathematics education students' SE in understanding mathematical concepts and their SE in problem-solving, with a Pearson's r of 0.70 and a p-value of less than 0.01. Students with high SE in understanding mathematics material also tend to have high SE in solving math problems. This is in line with research which states that students' SE in understanding the material and SE in solving mathematical problems is high [42], [43]. Additionally, this correlation has been shown to have a positive impact on students' academic performance, where high SE is associated with better academic achievement in mathematics courses [44], [45]. Moreover, SE has also been proven to have a positive influence on students' learning motivation and academic performance [22], [45], [46]. The implications of this research underscore the importance of adopting learning approaches that stimulate the development of SE in both aspects [4], [42], [45], [47] Providing appropriate support and guidance in building self-confidence in understanding

mathematical concepts and facing problem-solving tasks can help enhance the quality of learning and academic performance for mathematics education students.

Meanwhile, there is no significant relationship among the other variables. There is no significant correlation between biology education students' SE in understanding mathematical material and problem-solving in mathematics. This insignificant correlation indicates that the student's level of confidence in understanding mathematical material is not closely related to their level of confidence in solving mathematical problems. The level of SE in understanding mathematical material does not directly influence the student's ability to solve mathematical problems. This finding provides an understanding of the differences between academic disciplines and factors that may influence SE in the context of understanding mathematical material and solving mathematical problems [22]. The implications of these results can guide the development of more appropriate teaching strategies and underscore the importance of gaining deeper insights into biology education students' SE in understanding mathematical material and solving mathematical problems.

There is no significant correlation between biology and mathematics education students' SE in understanding mathematical material and problem-solving in mathematics. This finding indicates that the student's level of confidence in understanding mathematical concepts and solving mathematical problems is not closely related to the two fields of study. The results emphasize the importance of understanding the differences between academic disciplines and individual characteristics of students that may influence SE in understanding mathematical material and solving mathematical problems [22]. The implications of this research highlight the necessity for adapting more appropriate teaching approaches to enhance students' mathematical understanding abilities in biology and mathematics.

3.1.3. Difference self-efficacy understanding material and solving mathematical problems

The results of the analysis of normality between SE in understanding the material and SE in solving problems using the test of Normality Shapiro Wilk for biology and math students are presented in Table 5. The normality test results with Shapiro Wilk show that the data is normally distributed. Thus, the data meets the requirements for the t-test.

As presented in Table 6, it was found that there is no significant difference in the level of SE among biology education students when understanding mathematical material and when solving mathematical problems ($p > 0.05$). This finding indicates that biology education students feel equally confident in both aspects. This is in line with research which states that there is no significant difference in the creative problem-solving ability and SE of elementary school students, and there is no statistically significant difference in the level of SE of students concerning the preferred strategy for managing learning activities [45], [48]. The implications of this finding emphasize the importance of integrated teaching between mathematics and biology, as well as efforts to enhance students' problem-solving skills. Therefore, the results of this analysis can contribute to improving the quality of learning and fostering SE among biology education students in the context of mathematics.

Table 5. Test of normality (Shapiro-Wilk)

Variable		W	P
SE-material	Bio	0.972	0.130
	Math	0.987	0.153
SE-problem- solving	Bio	0.968	0.078
	Math	0.964	0.075

Note: Significant results suggest a deviation from normality.

Table 6. Independent samples t-test for SE

Variable	t	df	p
SE mathematics students	-7.02	308	<0.001
SE biology students	-0.08	132	0.93 ^a

Note: Student's t-test. ^aLevene's test is significant ($p < 0.05$)

On the other hand, there is a significant difference in the level of SE among mathematics education students when understanding mathematical material and when facing mathematical problem-solving. This is consistent with research findings suggesting that this difference may be attributed to variations in the learning context, the level of difficulty in problem-solving, and the problem-solving skills developed by students [49]–[51]. It indicates that students tend to be more confident in applying their mathematical knowledge to solve concrete problems rather than in understanding the theory or concepts of mathematics. This finding is essential to be understood in the context of mathematics education as it can provide insights into areas that need more attention to enhance students' SE. Teachers need to pay attention to these differences and develop

appropriate teaching strategies to enhance students' SE in mathematical problem-solving. Therefore, it is expected that students will be better prepared to face real-world mathematical challenges and feel more confident in applying their mathematical knowledge in more complex situations.

As shown in Table 7, there is a significant difference in SE between mathematics and biology education students in understanding mathematical material and solving mathematical problems, with a p-value of less than 0.05. Furthermore, the SE in understanding mathematical material among biology education students is higher than that of mathematics education students. On the other hand, the SE in solving mathematical problems among mathematics education students is higher than that of biology education students. The difference in SE between biology and mathematics education students in understanding mathematical material may be attributed to factors such as different learning contexts, prior learning experiences, psychological factors, and perceptions about mathematics [52], [53]. These findings provide important insights into how teaching approaches and psychological support can be tailored to help enhance students' SE in understanding mathematics and solving mathematical problems [54]–[56], especially for students whose main field of study is different from mathematics. Intensive problem-solving skills training and more relevant integration of mathematics into the biology education curriculum can help address these differences and strengthen students' SE in tackling complex and abstract mathematical tasks, thus promoting the improvement of biology education students' SE in mathematical problem-solving.

Table 7. Independent samples t-test SE mathematics and biology students

Variable	t	df	p
SE understanding material	2.42	220	0.02
SE problem solving	-3.48	220	<0.05

Note. Student's t-test.

3.2. Discussion

Based on the results of the descriptive analysis show that student SE in understanding the material, and student SE in solving math problems for prospective biology and mathematics education teacher students include low, moderate, and high categories. This is consistent with research showing that the influence on basic programming concepts is significant, particularly among students with medium and low SE [40]. Student SE and learning concepts have the potential to increase students' independent learning efficacy, as evidenced by conceptual understanding, high-level cognitive skills, practice, and communication [41]. Mathematics education students' SE in understanding the material and solving problems is primarily moderate, with low and high categories being relatively equal, indicating adequate confidence in mathematical abilities. There is little variation in student confidence levels, as evidenced by the minimal differences between low and high categories [51], [57]. According to studies, students with varying mathematical abilities exhibit varying levels of SE in problem-solving, with high-ability students excelling in problem-solving steps, medium-ability students demonstrating partial understanding, and low-ability students struggling to design and implement effective solutions.

Biology education students' SE in problem-solving is comparable to mathematics education students, with the majority falling into the moderate category [58]. However, significant differences emerge in SE for understanding the material, with biology students exhibiting low levels of confidence [59]. This suggests that, while students may feel capable of solving biological problems, they lack confidence in their understanding of the material. The disparity in SE levels between problem-solving and material understanding highlights the need for targeted interventions to boost students' confidence in effectively understanding biological concepts, potentially through tailored instructional approaches that address these specific SE perceptions. Teachers must focus on and strengthen student SE in two areas: understanding material and problem-solving. This can be accomplished by implementing learning strategies that increase student confidence, provide constructive feedback, and foster a learning environment that encourages exploration and experimentation.

The study's correlational analysis results show that there is a strong relationship between mathematics education students' SE in understanding mathematical concepts and their SE in problem-solving. This result is consistent with the findings of prior research, which stated that students' SE in understanding the material and SE in solving mathematical problems is significantly high [42], [43]. According to the result, mathematical SE is associated with engagement, persistence, and academic performance [34], [60]. Furthermore, encouraging independent learning of problem-solving tasks can improve self-monitoring and self-regulation, eventually improving performance in mathematics learning [61]. These findings also show that learning strategies that improve students' understanding of mathematical concepts can improve their problem-solving abilities. Learning strategies that emphasize a thorough understanding of mathematical concepts, such as the use of concrete examples, problem-based learning, and

visual representations, can assist students in developing a solid foundation for problem-solving skills. Teachers must not only focus on developing mathematical problem-solving skills but also on instilling confidence in students' understanding of the fundamental concepts. Teachers can help students succeed in mathematics by providing support and feedback that strengthens their SE in both of these areas.

Furthermore, the analysis found no significant relationship between biology education students' SE in understanding mathematical material and solving mathematical problems. There is no significant difference in SE between mathematics and biology education students when it comes to understanding mathematics material and solving math problems. Despite students' strong beliefs in their understanding of biology, this confidence has little impact on their mathematical problem-solving abilities. This suggests that SE in one subject is not always related to skills or beliefs in another [62]. While SE in mathematics is important for problem-solving, it may not be directly applicable across disciplines [58], [61], [63]. According to research, students' confidence in understanding and solving mathematical problems is not discipline-specific, implying that high confidence in mathematical abilities does not guarantee the same level of confidence in biology education. Task difficulty, emotional intelligence, and metacognitive awareness are important factors that shape students' attitudes and abilities in mathematics and other disciplines [64], [65]. As a result, improving SE and mathematics skills may necessitate a multi-disciplinary approach. These findings have significant educational implications because they demonstrate that approaches to increasing students' SE in one subject cannot always be applied directly to other subjects. Teachers must consider the specific factors that influence student SE in each subject, as well as develop appropriate learning strategies to boost student SE in that context. Furthermore, these findings emphasize the importance of an integrated learning approach in which students are given opportunities to develop their SE in various aspects of learning, such as material comprehension and problem-solving abilities. In this way, education can become more holistic, assisting students in developing the skills required for success in a variety of fields.

The t-test results revealed no significant difference in SE in understanding material and problem-solving among biology education students. This means that biology students are equally confident in their ability to understand material and solve problems. These findings are consistent with previous research indicating that students' SE in biology was not significantly related to their performance [66]. This demonstrates that there is no significant difference in SE for comprehending the material and solving problems [67], [68]. This information can help teachers and educational policymakers develop more holistic and integrated learning strategies that combine material understanding and problem-solving skills in biology education. Meanwhile, there are significant differences between mathematics education students. This demonstrates that mathematics education students have varying levels of SE in both understanding material and solving problems [45], [61], [69]. One possible interpretation is that mathematics education students may have greater self-confidence in understanding mathematical material than in solving concrete mathematical problems [45], [70]. The level of difficulty of the problem or the type of problem encountered in the context of mathematics learning may influence a student's confidence in solving it. These findings highlight the importance of considering non-academic factors in shaping student SE. Although the subject matter differs significantly between biology and mathematics, other factors such as peer and family support, perception of one's abilities, and level of motivation appear to have a greater influence on SE [33], [35]. These findings can help teachers and curriculum developers develop more focused learning strategies to increase mathematics and biology students' SE in understanding the material and solving mathematical problems.

The other findings reveal that there is a significant difference in SE levels between mathematics and biology education students when it comes to understanding mathematics material and solving mathematics problems. According to research, SE influences students' self-confidence and perceptions of mathematical material and problem-solving [59], [71]. These findings shed light on how various study programs can influence students' perceptions and confidence when dealing with mathematical material and problems. The research paper identifies several factors that contribute to the difference in SE levels between mathematics and biology education students. Mathematics education students tend to have higher SE due to increased exposure to mathematical material and intensive practice, which boosts their confidence in solving mathematical problems [62], [72]. Biology students, on the other hand, may not have received the same amount of exposure to mathematics content, resulting in lower SE in mathematics-related contexts [66], [73]. This disparity emphasizes the value of experience and practice in increasing SE, particularly in disciplines that require mathematical proficiency. These findings have significant implications for the development of effective learning strategies in both areas of study. To boost students' SE in understanding and solving mathematical problems, a learning approach that effectively integrates these two aspects is required, as is a greater emphasis on developing mathematical skills in all study programs. In addition, efforts must be made to raise biology students' awareness and interest in mathematics through relevant and engaging learning approaches. Increasing SE, particularly in disciplines that require mathematical knowledge.

4. CONCLUSION

Based on the findings and discussions, it is possible to conclude that students' SE in understanding the material and solving mathematical problems for mathematics education students and SE in solving problems for biology education students falls primarily into the medium category, while the low and high categories are balanced. The low category dominates biology education students' SE in understanding the material, whereas the medium and high categories are balanced. There is no significant relationship between SE in understanding mathematical material and solving mathematical problems for biology and mathematics. Meanwhile, there are significant differences between education students' biology and mathematics in the SE in understanding the material and solving mathematical problems. The study's limitations include its exclusive focus on mathematics and biology education students, potentially limiting the generalization of the findings to a broader student population. Therefore, future research should encompass participants from various educational disciplines to gain a more comprehensive understanding of SE in mathematics education and problem-solving.

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I : Investigation

R : Resources

D : Data Curation

O : Writing - Original Draft

E : Writing - Review & Editing

Vi : Visualization

Su : Supervision

P : Project administration

Fu : Funding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest regarding the publication of this paper.

DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author [B], upon reasonable request.

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